UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION III
1650 Arch Street
Philadelphia, Pennsylvania 19103-2029

DEC - 6 2018

SUBJECT: Request for Approval of a Funding Increase
For a Removal Action at the Safety Light Corporation Site
Bloomsburg, Columbia County, Pennsylvania

FROM: Ann DiDonato, On-Scene Coordinator
Eastern Response Branch (3HS31)

TO: Karen Melvin, Director
Hazardous Site Cleanup Division (3HS00)

THRU: Michael Towle, Chief
Eastern Response Branch (3HS31)

Bonnie Gross, Associate Director
Office of Preparedness and Response (3HS30)

Site ID # 03DG

I. PURPOSE

The purpose of this "Request for Approval of a Funding Increase" (Action Memorandum) is to document the need and approval of additional funding for the ongoing removal action at the Safety Light Corporation Superfund Site (Site) located in South Centre Township, Columbia County, Pennsylvania. The United States Environmental Protection Agency (EPA) has undertaken time-critical removal actions at the Site under the authority of Section 104 of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), 42 U.S.C. 9601 et seq., as amended, since 2004 (Removal Action). The history of the Removal Action at this Site is further described within Section II of this Action Memorandum. There are no nationally significant or precedent-setting issues associated with the response requested herein.

The On-Scene Coordinator (OSC) has evaluated available information and the current conditions at the Site pursuant to the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), 40 C.F.R. Part 300. The OSC finds that current conditions pose unacceptable threats which warrant continued Removal Action at the Site. Additionally, Site conditions and threats warrant continued exemption from the statutory limits found in CERCLA Section 104(c) of CERCLA, 42 U.S.C. § 9604(c), as indicated in Section V of this Action Memorandum. As such, continued removal action

appropriate and consistent with the ongoing Remedial Action, as discussed in Section II, below, at the Site is warranted.

Continued removal action requires additional funding to prevent or minimize the release and threat of release of radioactive substances from the Site. The Removal Action selected in this Action Memorandum will prevent or minimize the releases of hazardous substances, human exposure to hazardous substances, and the movement/migration of hazardous substances from the Site into the environment and the residential area which abuts the Site.

The Removal Action documented herein involves off-Site removal, treatment, and disposal of devices used to transport and store radioactive tritium gas (H3). The devices additionally contain finely shaved depleted uranium turnings. These devices are called 'Pyros' or 'getter bed' devices. The Pyros were discovered in 2013 and have proven difficult for EPA to dispose of from the Site throughout a long period of the successful removal action, which have included off-Site disposal of radioactive wastes.

To prevent or mitigate the additional releases/threatened releases identified in this Action Memorandum, the OSC requests a project ceiling increase of $3,720,000. The Removal Action at this Site has been described and selected in numerous Action Memoranda (previous Action Memoranda) which are further described in Section II below. To date, and documented in previous Action Memoranda, EPA has approved a combined project ceiling of $24,243,464. The additional funds requested herein will increase the project ceiling to $27,963,465.

II. SITE CONDITIONS AND BACKGROUND

This Action Memorandum requests funding for a time-critical Removal Action. The Removal Action for the Site was originally selected in an Action Memorandum signed July 2, 2004. Previous Action Memoranda, discussed in the Section II.B below, which increased funding, changed scope, or approved exemptions from the $2 Million and 12-Month Statutory Limits, were signed in April 2006, June 2007, October 2007, July 2008, January 2009, November 2012, February 2013, June 2013, December 2013, September 2014, June 2015, September 2015, and February 2016 (collectively referred to herein as "Previous Action Memoranda"). The Site was placed on the National Priorities List (NPL) on April 27, 2005. EPA issued a Record of Decision (ROD) for the Site on September 2, 2010 for Operable Unit (OU) 1, and an Early-Interim ROD for OU-3 on June 30, 2016. The Early-Interim ROD has been modified by Explanations of Significant Differences, dated August 24, 2017, and September 26, 2018.

Refer to Previous Action Memoranda for background information, in addition to the information contained in this 2018 Action Memorandum, which is specific to the removal action documented herein.

To date, EPA's Remedial and Removal Programs have been unable to dispose of the Pyros and they are simply being stored at the Site. The Pyros are currently leaking radioactive hazardous substances and actions are required to package, secure, and dispose of the Pyros to enable successful completion of EPA's response activity at the Site.

A. Site Description

1) Removal Site Evaluation

The Site includes a former facility (now demolished), which manufactured several types of products containing radioactive substances. The products included lighted products containing the radioactive gas tritium (H3). An assessment of several buldings at the Site in 2013 identified numerous items including the Pyros. The vast majority of the production materials, equipment items, devices, and wastes once contained in the former buildings have been disposed of over the years by EPA during its removal actions. However, EPA has thus far been unable to dispose of the Pyros.

The Pyro devices were used by Safety Light Corporation to transport and store H3 during the manufacture of lighted exit signs. These devices were made on-Site and consisted of finely shaved depleted uranium (DU) turnings, a highly reactive or 'pyrophoric' radioactive isotope which potentially may spontaneously combust in air. The DU provided an ionic bonding surface to "hold" the H3. One type of Pyro was heated up in a 'rig' during the exit sign manufacturing process and the H3 was driven off the DU material. With continual use, the bonding ability of the DU was lessened until it was no longer able to store significant amounts of H3 and became obsolete. However, H3 can still escape from these containers. According to conversations with a former employee of Safety Light, when a Pyro became obsolete, Argon gas was pumped into the device to reduce the potential for the DU to ignite. The device was then discarded on Site.

Shortly after the discovery of the Pyros in 2013, the OSC, along with Pennsylvania Department of Environmental Protection's (PADEP) Bureau of Radiation Protection (BRP), EPA's Consequence Management Advisory Division (CMAD), and EPA's Office of Radiation and Indoor Air (ORIA), began researching options for the treatment and disposal of the Pyros. Research for safe treatment and disposal of the Pyros continued for nearly four years. EPA, EPA's contractors, the U.S. Department of Energy, and/or BRP contacted all currently operating radioactive materials disposal facilities, as well as government facilities such as Brookhaven National Laboratory, Savannah River Systems, Los Alamos National Laboratory, Sandia National Laboratory, etc., regarding the treatment, storage and/or disposal of the Pyros. Not one of the facilities/laboratories was able to or willing to assist EPA with the treatment and disposal of the Pyros.

In 2016, testing performed by EPA's contractors on the Site confirmed that the Pyros still contain and/or have leaked tritium. Nine of the thirty-one devices were tested and all nine were determined to be leaking. In addition, bioassay tests to track human exposure from the Pyros were completed on any contract personnel that came in contact with the Pyros and exposures, some significant, were recorded. The devices are currently stored and monitored on the Site while EPA conducts other cleanup activities (described below).

In 2017, with EPA ORIA assistance, EPA's contractor secured a contract for a transportation and disposal 'test' of two of the newer devices, the only devices in which some information on the age or content of the Pyros was available. The company that accepted the Pyros for the 'test' experienced significant and unexpected contamination issues with the Pyros, as is detailed in the 'Depleted Uranium Tritium Getter Bed Processing Report' contained in the Administrative Record. However, after adjustments to equipment and process, the company was eventually able to successfully capture the H3 and render inert the pyrophoric DU.

The Pyros are currently stored in drums at the Site, contain an unknown amount of radioactive materials, require a security presence, and are leaking.

2) Physical Location

The Site is located along Old Berwick Road in a mixed residential and commercial neighborhood in Bloomsburg, Columbia County, Pennsylvania. The Susquehanna River courses alongside the southern boundary of the Site and flooding, including flooding of the Site, is a regular occurrence. Residential properties abut the north, east, and western boundaries of the Site. Hazardous substances from the Site migrated onto one adjacent residential property during a 2011 flooding event, which required cleanup by EPA.

3) Site Characteristics

The Site was once the location of Safety Light Corporation (Safety Light), which manufactured several types of products containing radioactive substances. The premises included numerous buildings in which production or the storage or other processing of radioactive materials was accomplished. The manufactured products included lighted products (e.g., lighted exit signs) containing H3. The buildings on the Site are now demolished and the vast majority of the wastes, once within those buildings, have been disposed of off-Site in accordance with Previous Action Memoranda.

The Site is currently subject to an EPA Remedial Action involving the removal and off-Site disposal of contaminated soil. A summary of the Removal Action at the Site is described in Section II.B of this Action Memorandum and in more detail in Previous Action Memoranda. The Site is privately owned by Safety Light, which is responsible for the contamination. Safety Light is currently performing very limited security and maintenance-related work activities at the Site.

4) Release or threatened release into the environment of a hazardous substance, pollutant or contaminant

The Pyro devices contain the radioactive elements tritium and depleted uranium. Radionuclides are hazardous substances designated at 40 C.F.R. § 302.4. Depleted uranium, as a reactive metal, is pyrophoric and will spontaneously combust when exposed to air.

The amount of radioactive material contained in the Pyros is not known and can only be estimated. If the Pyros are at their storage capacity, disposal options are extremely limited. Leak testing of these devices has determined that the devices are leaking H3. Based upon the information available, a release of radioactive materials is occurring and will continue to occur if appropriate measures are not taken to remove the devices from the Site for proper off-Site disposal.

Radioactive tritium gas releases in the air from the Site may impact nearby residences in the future. Residential areas are located directly to the north of the Site, across Old Berwick Road and directly to the east and west of the Site. The Susquehanna River is the southern border of the Site and flooding of the area is a regular occurrence. Flooding from the Susquehanna River may release hazardous substances from the Site and may impact the Pyros while stored on Site. The Pyros are leaking and exposure to EPA and contract personnel from the H3 has been documented. Since trespassing has been documented several times at the Site, both residents and trespassers also may become exposed to the hazardous substances located at the Site if further action is not taken.

5) National Priority Listing

The Safety Light Corporation Site was listed on the National Priorities List (NPL) on April 27, 2005.

B. Other Actions to Date

A brief synopsis of removal actions is below. See Previous Action Memoranda for additional information.

1) Previous Actions

EPA selected a time-critical removal action at the Site in July 2004 addressing the disposal of certain radioactive wastes from within an underground "silo" at the Site. These waste items were not effectively addressed by the Site owners. In April 2006, the funding ceiling for the removal action was increased and exemption from the 12-Month and $2M statutory limits ("emergency waiver") was approved to complete characterization of the wastes and conduct off-Site disposal.

EPA's contractors were unable to conduct disposal and EPA executed an Interagency Agreement with the Army Corps of Engineers in 2005 to ultimately conduct disposal of the silo wastes. The silo wastes were removed from the Site and shipped in 2007 to a facility in Texas where they remained in storage for years. EPA ultimately entered into a direct negotiated contract ($2,936,176) for disposal of the silo wastes in 2013, directly issuing a Procurement Request to a waste company in Texas capable of properly disposing of the waste.

On June 21, 2007, EPA approved a non-time-critical removal action concerning the demolition of seven on-Site buildings and also approved an increase to the removal ceiling and an exemption from the $2M statutory limits (using the "consistency waiver" under Section 104(c) of CERLCA, 42 U.S.C. § 9604(c)) to conduct demolition and disposal activities. The June 2007 action did not include the Main Building or the Butler Building where wastes were being consolidated and staged and several other on-Site structures (e.g., water tower). The funding ceiling for this non-time-critical activity was increased in July 2008.

On October 22, 2007, EPA issued an Action Memorandum pertaining to the operation and maintenance of the safety/security systems for certain remaining buildings at the Site, including the Main Building. On November 13, 2007, EPA issued a Unilateral Administrative Order (UAO) to Safety Light Corporation, Metreal Corporation and Isolite Corporation, requiring certain maintenance activities at the Site. Safety Light currently performs very limited security and maintenance-related work activities at the Site.

On January 22, 2009, EPA issued an Action Memorandum, which focused on the removal of soil from a residential property adjacent to the Site. The soil was removed.

On September 2, 2010, EPA's Remedial Program issued a ROD for OU-1, which selected a remedy consisting of the demolition of the Main Building and other remaining structures on-Site. However, implementation of the selected remedy was delayed due to funding issues.

In October 2012, the Remedial Program requested that the Removal Program review a draft structural evaluation report and consider whether a removal action would be appropriate to complete structural repairs to the Main Building. As a result of a Removal Site Evaluation, EPA initiated a time-critical removal action at the Site on November 8, 2012. The 2012 Action Memo changed the scope of the Removal Action, raised the ceiling, and continued to exempt the Removal Action from the 12-month statutory limits based upon the "consistency waiver." The 2012 Action Memo was intended to stabilize

the Main Building in the 3- to 5-year term to prevent the release of radionuclides staged therein to the environment while awaiting funding to implement the Remedial Action.

During the implementation of the 2012 Action Memo, additional removal actions were identified as being necessary to prevent identified unacceptable threats involving the release or threat of release of hazardous substances from the Site. On February 20, 2013, EPA issued another Action Memo, to increase the funding and change the scope of the Removal Action based on these newly identified threats.

In the spring of 2013, the Remedial Program requested that the Removal Program assess the 'Solid Waste' building (a small outbuilding at the Site) and its contents. The Solid Waste building was adjacent to the Susquehanna River and was flooded during Tropical Storm Lee in 2011. The OSC directed the EPA contractor to complete an assessment of the Solid Waste building and all other remaining outbuildings in or near the flood plain of the Susquehanna River. During the assessment activities, numerous radioactively-contaminated items (inclusive of the Pyros) and radioactive sources were identified/consolidated/secured in the Main Building and in more secure outbuildings. In addition, the Removal Program reviewed the current status of one of the locations on the southern portion of the property called the 'West Dump,' which had eroded onto an adjacent residential property after being flooded during Tropical Storm Lee.

To address these additional threats, EPA approved a change in the scope and additional funding for the Removal Action on June 11, 2013. The activities undertaken pursuant to the June 2013 Action Memorandum resulted in the removal and off-Site disposal of most radiologically contaminated items from the Site, the construction of an engineered cap for the West Dump, and additional security of the premises. However, EPA was unable to locate an off-Site disposal facility for the Pyros.

On December 16, 2013, as the structural integrity of the remaining on-Site buildings continued to decline, EPA approved additional funding and a change in the scope of the Removal Action to conduct the demolition and disposal of the Main and Butler Buildings, the demolition and recycling of the elevated Water Tower, and the recycling of portions of the clean structural steel located in the Butler Building. As part of the Removal Action approved in December 2013, EPA completed asbestos abatement in all structures containing asbestos prior to demolition, and assessed, removed, and disposed of underground storage tanks.

Beginning in July 2014, EPA commenced the Remedial Action selected in the OU-1 ROD and funded by the Remedial Program, including demolition of the Tritium Building, the Machine Shop, and the Boiler Room, as well as the removal of the foundations of the buildings demolished during the 2013 and 2014removal actions and recycling of the on-Site unaffected Water Tank. EPA completed the OU-1 Remedial Action in September 2015 except for the off-Site disposal of a limited amount of source materials removed from the buildings. Due to the unique nature of some of these items (e.g., pyros), EPA considered long term on-Site storage necessary.

On September 26, 2014, EPA changed the scope of the Removal Action and approved additional funding for removal of underground storage tanks and associated piping, removal of associated soil contamination from the tanks/piping as practicable, and the assessment and removal of discrete radiologically contaminated objects and associated soils.

On June 17, 2015, EPA again changed the scope of the Removal Action and approved additional funding to continue removal and off-Site disposal of buried radioactively- contaminated items and soils

located at the Site (primarily from the areas under the former building foundations and adjacent to and in the flood plain of the Susquehanna River) and to stabilize areas of disturbed soil through limited capping to prevent movement/migration of radioactive material from the Site in the event of a flood.

On September 18, 2015, EPA changed the scope of the Removal Action and approved additional funding to address the discovery of numerous high activity, radiologically- contaminated items and soil in the areas of the West Lagoon, East Lagoon and East Dump. EPA changed the scope of the Removal Action again on February 1, 2016, to both continue the Removal Action and include construction of an engineered cap for those areas.

On June 30, 2016, EPA's Remedial Program issued an Early-Interim Record of Decision for OU-3, continuing the work detailed in the February 2016 Action Memorandum. Specifically, the Early-Interim ROD provided for additional excavation of the West Dump, West Lagoon, East Dump, and East Lagoon areas of the Site. The Remedial Program issued an Explanation of Significant Differences (ESD) on August 24, 2017, to address additional areas for excavation of radionuclide-contaminated soils/debris, including radioactive discrete objects in the 100-year floodplain, within and immediately adjacent to the abandoned canal on the Site. On September 26, 2018, the Remedial Program issued a subsequent ESD to continue excavation in the 100-year floodplain, within and immediately adjacent to the abandoned canal up to and including the entire length of the canal on the Site, as necessary.

All activities detailed in the July 2004, April 2006, June 2007, October 2007, July 2008, and January 2009 Action Memoranda are complete. All activities detailed in the November 2012, February 2013, June 2013, December 2013, September 2014, June 2015, September 2015, and January 2016 Action Memoranda and the June 2016 Early-Interim ROD are substantially complete. The Removal Program still needs to conduct limited disposal activities related to source materials remaining on-Site (Pyros). Remedial Actions at the Site are ongoing related to the ESDs referenced in the following 'Current Actions' section.

Some of the radioactively-contaminated items identified during the June 2013 Removal Action activities are those items (Pyros) for which a disposal option was unable to be determined. The off-Site disposal of the Pyros is the subject of this 2018 Action Memorandum.

2) Current Actions

As stated above, Remedial Actions at the Site are ongoing. EPA's Remedial Program issued an ESD on August 24, 2017, and again on September 26, 2018, to continue excavation of radionuclide-contaminated soils/debris, which include radioactive discrete objects in the 100-year floodplain, within and immediately adjacent to the abandoned canal, up to and including the entire length of the canal on the Site, as necessary. The past and ongoing actions taken to date at the Site have been effective for all media and threats, with the notable exception of the Pyros.

C. State and Local Authorities Role

EPA's Remedial Project Manager (RPM) and OSC continue to coordinate with the Nuclear Regulatory Commission (NRC), PADEP's BRP, and PADEP's Hazardous Site Cleanup Act (HSCA) Program. However, EPA is the Lead Agency at the Site.

III. THREATS TO PUBLIC HEALTH OR WELFARE OR THE ENVIRONMENT

Section 300.415 of the NCP lists the factors to be considered in determining the appropriateness of a Removal Action. Paragraph (b)(2)(i), and (vii) of Section 300.415 directly apply to the conditions at the Site.

300.415 (b) (2) (i) "Actual or potential exposure to nearby human populations, animals or the food chain from hazardous substances or pollutants or contaminants"

The Pyros contain an unknown amount of pyrophoric depleted uranium and tritium gas, both of which are radioactive elements and hazardous substances designated in 40 C.F.R. § 302.4. The radioactively-contaminated buildings in which the devices were stored have been demolished and disposed of off-Site. The devices are leaking and are currently stored within drums on the Site as EPA conducts other cleanup activities under the Early-Interim ROD. After EPA completes its current removal and remedial activities, the devices will still be stored on-Site, requiring security until proper off-Site disposal options are approved. Residential areas are located directly to the north of the Site, across Old Berwick Road, and directly to the east and west of the Site. The Susquehanna River is the southern border of the Site and flooding of the area is a regular occurrence. Trespassing has been documented several times at the Site, and both residents and trespassers may become exposed to hazardous substances located at the Site if further action is not taken. The Pyros are leaking, and EPA has documented exposure to EPA and contract personnel from the H3. The release of hazardous substances from the Pyros poses a threat to any persons in contact with the devices or working to dispose of the devices, as those persons are likely to be exposed to radioactive substances leaking from the Pyros. Additionally, until the Pyros are removed from the Site, they pose a threat of release of hazardous substances to the environment in flooding or other uncontrolled situations.

300.415 (b) (2) (vii) "The availability of other appropriate federal or state response mechanisms to respond to the release"

The federal Nuclear Regulatory Commission (NRC) and PADEP's BRP and HSCA programs, which are potential response agencies for the Site, have indicated that they do not have the resources to fund response actions at the Site. In addition, the owner and former operator of the facility, Safety Light, has continually asserted that it has insufficient funds to perform any further response actions at the Site.

IV. ENDANGERMENT DETERMINATION

Based upon information gathered during the assessment of the Site, as described above, the actual or threatened releases of hazardous substances from this Site, if not addressed by implementing the response action selected in this Action Memorandum, may present an imminent and substantial endangerment to public health, welfare, or the environment.

V. EXEMPTION FROM STATUTORY LIMITS

The deteriorating conditions warranting exemption from the 12-Month and $2 Million Statutory Limits at this Site, as documented in Previous Action Memoranda, still exist. In accordance with CERCLA § 104(c)(1)(C), 42 U.S.C. § 9604(c)(1)(C), continued response actions at the Site are appropriate and consistent with the selected Remedial Action.

Specifically, the Removal Action documented herein is fully consistent with the Remedial Action selected for the Site and any Remedial Action that may be selected in the future. All source materials, such as the Pyros, found at the Site will require off-Site disposal to protect human health and the environment and to prevent the release of radioactive materials into the surrounding community. Implementation of this Removal Action is necessary and appropriate to avoid foreseeable threats posed by the Pyros, by transporting the Pyros off-Site, and arranging for their proper off-Site disposal. The OSC and RPM have and will continue to fully coordinate on all activities at the Site.

VI. PROPOSED ACTIONS

The proposed actions are intended to mitigate the threat posed to the public health and welfare and the environment due to actual and/or substantial threat of release of hazardous substances – radioactive pyrophoric depleted uranium and radioactive tritium gas – from the Site. The proposed actions will stabilize the Site, until further actions by the Remedial Program can be implemented in accordance with any future RODs. The OSC will continue to coordinate with the RPM regarding all site activities.

A. Proposed Actions

1) Description of Proposed Actions

a. Secure the Pyros containing tritium and depleted uranium in advance of Site demobilization;
b. Monitor security of the Pyros following Site demobilization and prior to shipping;
c. Prepare the Pyros for off-Site treatment and disposal;
d. Furnish all equipment, labor, supervision and material necessary to transport, treat, and dispose of the Pyros; and
e. Dispose of the Pyros off-Site, in accordance with CERCLA § 121(d)(3) and 40 C.F.R. § 300.440.

2) Contribution To Remedial Performance

The Site is on the NPL. The Removal Action at the Site is consistent with the requirement of Section 104(a)(2) of CERCLA, 42 U.S.C. § 104(a)(2), which states that a removal action should, to the extent practicable, contribute to the efficient performance of any long-term remedial action.

3) Compliance with ARARs

The proposed Removal Action will comply with Federal and State ARARS to the extent practicable considering the exigencies of the situation. The OSC requested that PADEP submit additional applicable ARARs, if necessary. PADEP's BRP and HSCA Programs have both indicated that there are no additional ARARs to consider for the proposed action.

4) Project Schedule

Due to the numerous unknowns related to the Pyros, such as quantity of radionuclides contained in the devices, the action may take 6 months to 3 years to implement.

5) Estimated Costs

This Action Memorandum adjusts the project ceiling for the Site to properly account for the costs relating to the characterization and disposal of the silo wastes.

The proposed distribution of funding for this Action Memorandum is as follows:

Regional Removal Allowance Costs Total Cleanup Contractor Costs (ERRS)	$0
Other Extramural Costs Not Funded from the Regional Allowance	$3,100,000
Extramural Contingency	$620,000
Total Removal Action Project Ceiling For this Action	$3,720,000

Extramural costs	Previous	This action	New
Regional Allowance	16,665,322	0	16,665,322
Other extramural	4,088,077	3,100,000	7,188,077
Contingency	3,490,065	620,000	4,110,065
Total	24,243,464	3,720,000	27,963,464

VI. EXPECTED CHANGE IN THE SITUATION SHOULD ACTION BE DELAYED OR NOT TAKEN

If a removal action is not taken or is significantly delayed, the subsequent release of hazardous substances and radionuclides to the adjacent community and environment may occur. Flooding has been a continual concern with the most recent severe flooding event occurring in September of 2011. Trespass has been a historical problem at the Site and the Pyro devices have been determined to leak radioactive gas.

VII. OUTSTANDING POLICY ISSUES

There are no known outstanding policy issues pertaining to the Site.

VIII. ENFORCEMENT

The OSC will coordinate with the RPM regarding enforcement/cost recovery, as necessary. See the attached Confidential Enforcement Addendum.

The total EPA costs for this removal action based upon full-cost accounting practices that will be eligible for cost recovery are estimated to be $6, 240,360.[1]

Direct Extramural Costs	$3,720,000
Direct Intramural Costs	$80,000
Total, Direct Costs	$3,800,000
Indirect Costs (64.22 % x Direct Costs)	$2,440,360
Estimated EPA Costs for a Removal Action	$6,240,360

IX. RECOMMENDATION

This Action Memorandum represents the selected Removal Action for the Safety Light Corporation Superfund Site in Bloomsburg, Pennsylvania, developed in accordance with CERCLA, as amended, and is not inconsistent with the NCP. This decision is based on the Administrative Record for the Site.

By signing this Action Memorandum, you are also hereby establishing the documents listed in Attachment B, Administrative Record Index, as the Administrative Record supporting the issuance of this Action Memorandum, pursuant to Section 113(k) of CERCLA, 42 U.S.C. § 9613(k), and EPA Delegation No. 14-22.

Because conditions at the Site meet the removal action requirements of the NCP, I recommend your approval of the proposed Removal Action. The total Removal Action Project Ceiling, if approved, will be $27,963,464. Of this, an estimated $24,24,464 comes from the Regional Removal Allowance. Please indicate your approval or disapproval below.

Action by the Approving Official:

I have reviewed the above-stated facts and based upon those facts and the information compiled in the documents described above, I hereby determine that the release or threatened release of hazardous substances at and/or from the Site presents or may present an imminent and substantial endangerment to the public health or welfare or to the environment. I concur with the recommended removal action as outlined.

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[1]Direct Costs include direct extramural costs and direct intramural costs. Indirect costs are calculated based on an estimated indirect cost rate expressed as a percentage of site-specific direct costs, consistent with the full cost accounting methodology effective October 2, 2000. These estimates do not include pre-judgment interest, do not take into account other enforcement costs, including Department of Justice costs, and may be adjusted during the course of a removal action. The estimates are for illustrative purposes only and their use is not intended to create any rights for responsible parties. Neither the lack of a total cost estimate nor deviation of actual total costs from this estimate will affect the United States' right to cost recovery.

APPROVED: _____ 12-6-13

Karen Melvin, Director
Hazardous Site Cleanup Division
EPA Region III

Date

ATTACHMENTS:

A. Confidential Enforcement Addendum
B. Administrative Record Index

Torion Plasma Corporation
240 Melrose Ave
King City, ON, L7B 1J7
Tel: 647-889-6004

Torion Plasma Corporation

Depleted Uranium Tritium Getter Bed Processing Report

Customer: Kemron Environmental Services

Project Name: Safety Light

Proposal No: IFB SF2007-527

Overview

The US. EPA Region III has a need to dispose of 31 depleted uranium (DU) tritium getter beds (Ubed) that were discovered on the Safety Light Corp site. These Ubeds were assessed by Weston Solutions on November 16, 2015 and detailed in their report Doc Control No: W0025.1A.01692. The two key concerns regarding the disposal of the Ubeds were the quantity of tritium in each Ubed was not quantified and the depleted uranium is pyrophoric. These concerns suggested expensive options to measure the quantity of tritium on the Ubeds with a calorimeter and further expense on the disposal of the tritium along with the pyrophoric material.

After meeting with representatives from the EPA at a health physics conference in Spokane in 2017, NSSI offered a more environmentally friendly and cost effective method to treat the Ubeds. The NSSI facility has the capability to unload, capture and measure the amount of tritium on the Ubeds, regardless of the quantity, and then chemically passivate the depleted uranium to an inert uranium oxide. The unloaded, stable, non-pyrophoric Ubeds could then be cost effectively disposed of as low level active metal waste without the D003 code.

To test this approach the EPA contracted Kemron Environmental Services, Inc to engage NSSI to treat two of the Ubeds (SWB-092 and UNK-001) in this manner under proposal IFB SF2007-527. The Ubeds arrived at NSSI in March 2017 and they were both treated successfully by July 2017. This report will detail the efforts and lessons learned in treating the first two Ubeds and to provide a cost effective procedure for treating the remaining 29 Ubeds.

Project Timeline Summary

Date	Action
Dec 9, 2016	Contract with Kemron was signed
March 26 2017	Single 55 Gal drum containing SWB-092 and UNK-001 arrived at facility
April 1, 2017	Ubeds unpackaged, outgassing caused potential dose and a registrable tritium release
April 2, 2017	Ubeds secured in an air glove box to outgas down to safe levels

May 8-11, 2017	Unloading station upgraded to handle potential outgassing
May 27, 2017	SWB-092 unloaded and passivated
July 27, 2017	UNK-001 unloaded and passivated
Aug 25, 2017	Report Prepared

Receiving

The two Ubeds SWB-092 and UNK-001 arrived at NSSI in the 55 gallon overpack shown in Fig 1 with appropriate labeling.

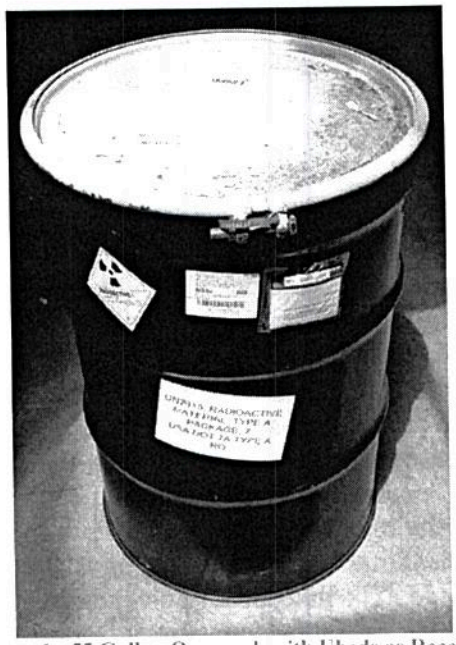

Figure 1: 55 Gallon Overpack with Ubeds as Received

The 55 gallon overpack was staged in a receiving area with good air flow in preparation for opening. A facility technician in appropriate personal protective equipment (PPE) undid the bolt on the overpack. A handheld tritium in air monitor (Overhoff) was used to sample the air inside the 55 gallon overpack (see Fig 2) to determine if it was safe to continue work. During the air sampling with the Overhoff a dose significant amount of tritium was measured when the overpack was opened. According to the safety procedures all personal left the receiving area until the tritium activity dropped below 5 $\mu Ci/m^3$.

Figure 2: Hand Held Tritium in Air Monitoring for Activity

Once the receiving area was safe to re-enter the lid of the 55 gallon overpack was pulled back to reveal the 5 gallon pail shown in Fig 3 with no packing material. Two Ubeds were found inside the 5 gallon pail individually wrapped in a clear thick plastic bag with a zip tie holding them shut.

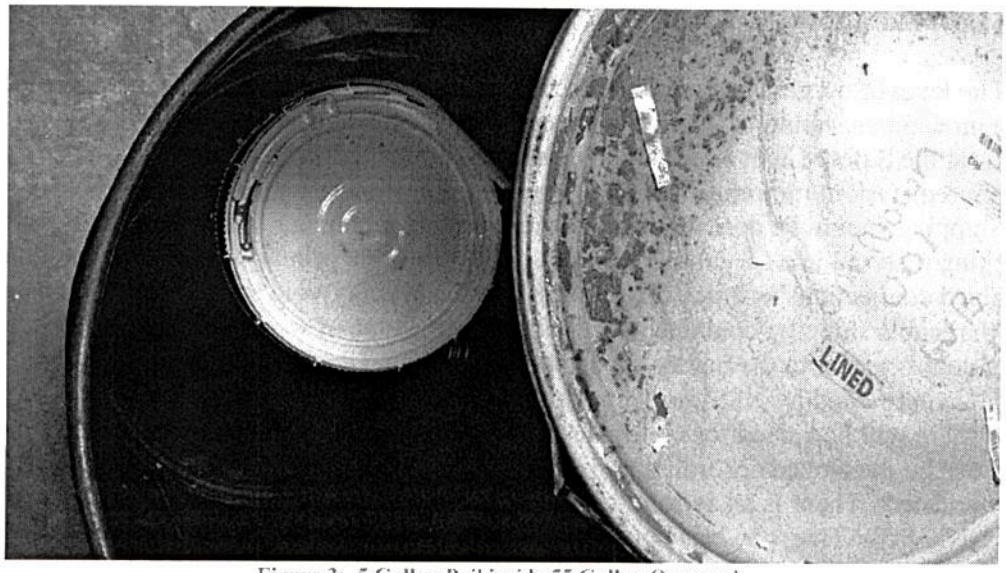

Figure 3: 5 Gallon Pail inside 55 Gallon Overpack

The 5 gallon pail was removed and placed inside the transport air box within the facility (see Fig 4). This air box is designed to receive and outgas materials to safe handling levels. The 5 Gallon pail was opened inside the air box and the plastic bags were cut opened to allow for all trapped air volumes to escape. The Ubeds were left in the transport box for 2 months while the unloading station was upgraded to handle this unexpectedly high outgassing rate.

Figure 4: NSSI Facility Transport Air Box

Lessons Learned

The level of outgassing from the Ubeds was more than expected. The storage and shipping procedures should be changed to accommodate this outgassing. It is recommended that the Ubeds at the Safety Light site should be stored in containers with a steady air purge directed to a monitored stack to minimize buildup of dose significant amounts of tritium activity.

Shipping should be done with a purgeable primary container that is then held securely with packing material in a 55 gallon overpack. The purgeable primary container should have either valved connections or quick disconnects into the primary void space. NSSI has a certified Type A purgeable shipping container that is used for this type of work (see Fig 5). This container could be sent to the Safety Light site, loaded with Ubeds, and then placed in an overpack also provided by NSSI for shipment back to NSSI. Due to the volume in the NSSI container there will be a need for multiple shipments to accommodate all of the beds. A shipping schedule can be developed according to the size of the Ubeds and the estimated activities if this option is selected. There is an added advantage for the two unknown paint cans labeled UNK-002 and UNK-003. They can be safely shipped to NSSI and opened in the transport air box under controlled conditions. The internal Ubeds can then outgas to safe levels before being unloaded and passivated.

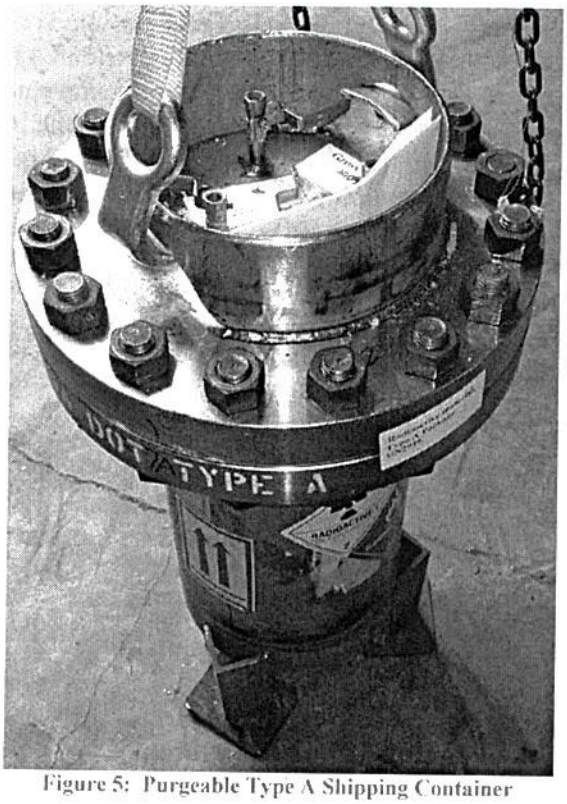

Figure 5: Purgeable Type A Shipping Container

To minimize tritium activity buildup inside of the primary shipping container the Ubeds should remain inside the onsite air box until the shipping paperwork is ready. The Ubeds will then be moved from the onsite air box to the purgeable NSSI container, packed securely into the overpack and then sent with priority overnight delivery to the NSSI facility. At NSSI the purgeable container will be removed from the overpack, the primary void space purged of all tritium activity and the Ubeds removed and placed into the transport air box to wait for processing. Through this shipping procedure all tritium activity arising from outgassing will be safely contained and controlled, thereby minimizing exposure to the public.

Unloading Station Upgrade

To accommodate the two Ubeds for the Kemron contract, the bed unloading station was upgraded. Initially the plan was to upgrade the gas handling system to allow for the full capture and assay of the tritium but an additional air box was also included after the outgassing issue was discovered.

A new air box was installed next to the bed unloading station and was plumbed into the upgraded gas handling system (see Fig 6). The process flow diagram (see Fig 7) describes the new gas handling system. In order to capture and assay the tritium gas from the Ubed a pressure

transducer (PT1), high level tritium monitor (TM1) and cryopump (CP1) were installed off the main vacuum pump (Vac) system. The cryopump is a small volume of molecular sieve that can be cooled to liquid nitrogen temperatures in order to pump all tritiated hydrogen off the Ubed as the bed is heated. The Ubed can then be isolated and the cryopump can be heated to release and expand the hydrogen into 0.5 L transport vessels (TV1,2,3 or 4). The pressure sensor and tritium monitor connected to the manifold can be used to determine the total quantity and activity of gas stored in the transport vessels. Any remaining gas can be reabsorbed onto the cryopump or pumped to the mixed waste oxidation system (MWOS) using the vacuum pump. Once all tritium has been unloaded from the Ubed, hydrogen can be introduced in a controlled manner using the Hydrogen mass flow controller (MFC1) for the purpose of isotopically washing tritium from the Ubed. Finally the oxygen mass flow controller (MFC2) can introduce known quantities of O2 into the Ubed for chemically passivating the depleted uranium.

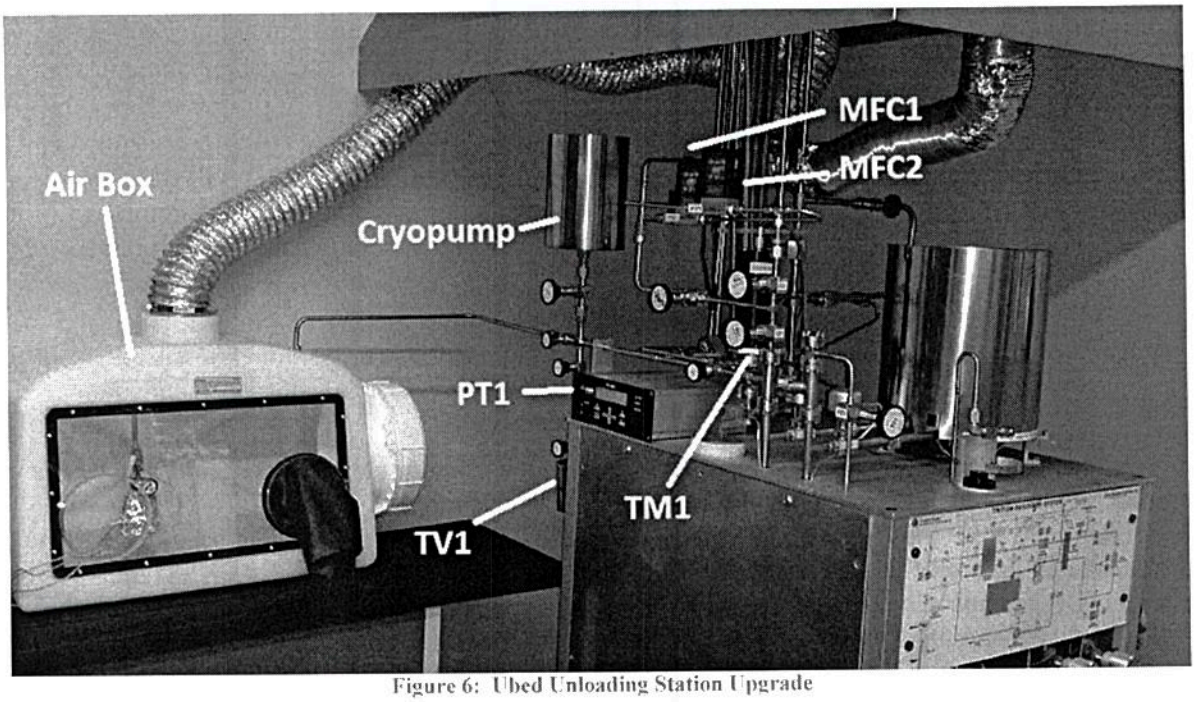

Figure 6: Ubed Unloading Station Upgrade

With the new piping and equipment in place, the Ubed can be:

- unloaded,
- evacuated,
- flushed with hydrogen and,
- chemically passivated with oxygen with all effluent being directed into the mixed waste oxidation system for oxidation and capture.

The tritium that has been collected can be:

- assayed,
- loaded onto a transport vessel for a secondary assay and,
- recycled for re-use,

This system provides a high degree of flexibility with no release to the environment.

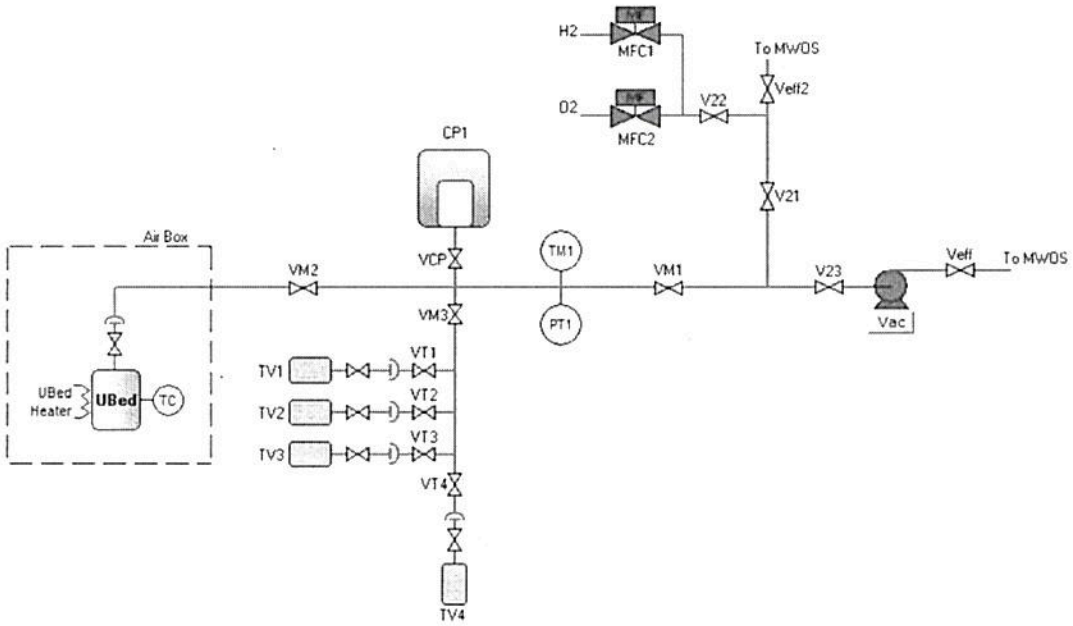

Figure 7: Process Flow Diagram

Processing Procedures

The treatment of each bed proceeds in four consecutive stages: evacuating the system, tritium unloading, hydrogen flushing of the Ubed and oxygen passivation. The last two steps need be done multiple times in order to fully passivate the depleted uranium and to verify that the DU is passivated. The cycling is necessary to physically break up the depleted uranium in order to expose the bulk of the material for tritium removal and further passivation. The number of cycles will depend on the pressure profile of the gases loading onto the Ubed. If the Ubed will no longer absorb hydrogen then it has been rendered chemically inert, that is to say and the DU has been converted to oxides of DU.

Tritium unloaded from the Ubed is captured by the cryopump and then transferred to the transport vessels. If there is a significant amount of gas during the tritium unloading then the first hydrogen wash will also be captured and transferred to a transport vessel. The subsequent oxygen and hydrogen cycles will not carry any significant amount of tritium so that gas is directed to the mixed waste oxidation system (MWOS) for hydrogen oxidation and capture on driers to minimize releases. The transport vessels are then sent to the University of Rochester, Lab for Laser Energetics (UofR) for tritium gas enrichment to 99.9% in their isotope separation system (ISS) and then used for fusion experiments.

The quantity of activity collected in the MWOS is negligible and cannot be measured within the system. Instead the tritium monitor on the outlet of the system is used to confirm there are no tritium releases.

The following procedures will discuss each stage of the Ubed processing. Please refer to Fig 7 for the referenced components.

System Evacuation

The Ubed to be unloaded and passivated is connected to the system via the VM2 line. The heater and thermocouple are also connected to the temperature controller to allow for heat control.

Before unloading the tritium from the Ubed the system will be evacuated. The vacuum system is established by opening V23, Veff and turning on the Vac pump. The effluent from the vacuum pump is directed into the MWOS to capture any residual tritium in the gas stream. The MWOS is able to handle hydrogen, air or oxygen and effectively capture 99.999% of all activity. Once the vacuum loop is operational and established it may be controlled using the manual valve V23 to either apply or isolate the vacuum loop.

The primary manifold is first evacuated by closing V21, VM2, VM3 and VCP. VM1 is opened and V23 is opened. The pressure at PT1 is monitored until it is below 2 torr. The gas lines are then evacuated by opening V21 and V22 to confirm there is no residual gas. The cryopump which is at room temperature is then evacuated by opening VCP. When the pressure at PT1 is below 2 torr the cryopump is isolated. The transport manifold is evacuated by opening VM3 and then each vessel is evacuated in series from VT1 to VT4. Once all vessels are below 2 torr they are individually isolated and the transport manifold is isolated. Finally the line to the Ubed is evacuated by opening VM2. The Ubed isolation valve remains closed for this operation so only the line to the Ubed is evacuated.

After remaining unused for many years the Ubed will have a vapor pressure of gas comprising helium-3 and tritium above the depleted uranium. The volume and activity of this gas will provide useful information. This gas was captured and measured by expanding the Ubed head pressure into the primary manifold. VM1, VM3 and VCP are closed while VM2 is opened providing an evacuated primary manifold to accept the gas. The Ubed, which is at room temperature, is opened to the manifold using the Ubed isolation valve. The pressure in the manifold is monitored and recorded using PT1. The activity of the gas is monitored using the tritium monitor TM1. Once the gas has been measured it will be evacuated by opening V23. Once PT1 is below 2 torr the vacuum system is isolated using V23. Now all lines and the Ubed are fully evacuated and ready for unloading.

Tritium Unloading

The tritium gas on the uranium will be unloaded into the primary manifold by slowly heating the Ubed up to 500 C. The cryopump will be prepared to accept gas by filling the cooling chamber with liquid nitrogen to cool the cryopump to LN temperatures. The pressure in the manifold will be monitored until 700 torr. As the pressure exceeds 700 torr the gas will be pumped onto the cryopump (CP1) for temporary storage by opening valve VCP. Once the

majority of gas from the manifold has been pumped onto CP1, valve VCP will be closed again to repressurize the primary manifold. This procedure will continue until there is no more gas evolving from the Ubed (the pressure will remain steady and close to zero). The final quantity of gas in the manifold will be collected into the CP1. The pressure peaks from this operation can be used to estimate the quantity of gas extracted from the Ubed that is now on the CP1 and the number of transport vessels that will be needed.

To unload the cryopump into the transport vessels the transport manifold is opened via VM3 and the first transport vessel is selected by opening VT1. If the quantity of gas is determined to be more than 0.5 L then additional transport vessels can be opened to accept the gas volume without exceeding 750 torr. Once the TV's are in the line the cryopump is opened by VCP and is heated to desorb the gas. The pressure sensor (PT1) is monitored to confirm that the pressure does not exceed 750 torr. If the pressure does get above 700 torr then an additional TV can be opened to lower the pressure. Once the cryopump is at room temperature all the gas is released. The pressure sensor (PT1), tritium monitor (TM1) and number of transport vessels will be used to determine the quantity of gas and the tritium activity. All TV's are then isolated by closing their valves.

To clean up the remaining activity a final TV is opened to the manifold and cryopump to evacuate the remaining gas into the transport vessel. This final vessel is then isolated and the cryopump and manifolds are then evacuated to the MWOS by opening V23. Once the pressure of the manifold and cryopump are below 2 torr they can be isolated by closing VCP, VM3, VM1 and V23. The heater on the Ubed can be turned off to allow the Ubed to return to room temperature in preparation for the first hydrogen wash. The tritium has been successfully unloaded from the Ubed, characterized and stored on the transport vessels. The transport vessels may be removed, capped, cleaned of surface contamination, marked and prepared for shipping to UofR

Hydrogen Wash

Hydrogen is loaded onto the Ubed in a controlled manner by filling the evacuated manifold with hydrogen via the H2 mass flow controller (MFC1). Valve VM1, V21 and V22 are opened and MFC1 is set at 0.2 SLPM of gas flow. When PT1 reaches 700 torr the hydrogen supply is isolated by shutting VM1, V21, V22 and setting the MFC1 to 0 SLPM. The hydrogen in the manifold is then exposed to the Ubed by opening valve VM2 and the Ubed isolation valve. The drop in pressure will determine the total volume of gas that is absorbed onto the Ubed and can be used to determine the amount of DU that is still active within the Ubed. If the pressure drops below 2 torr then the loading step is repeated with another charge of hydrogen until the bed can no longer pump.

The activity and volume of the gas from the tritium unloading stage will determine if the first hydrogen wash needs to be captured or if it can be sent to the MWOS. If the activity is considerable (> 50 Ci) then the first hydrogen wash is unloaded from the Ubed by using the Tritium Unloading procedure described earlier.

To unload the Ubed directly to the MWOS the manifold, Ubed head space and supply gas lines are evacuated by opening V23, V21, V22, VM1, VM2, and finally the Ubed isolation valve. When PT1 is below 2 torr the vacuum and the supply gas lines are isolated by closing

VM1, V21, V22, and V23. The Ubed is heated to 500 C to desorb the hydrogen from the depleted uranium. If the volumetric capacity of the Ubed is larger than the manifold volume to hold the hydrogen below 800 torr, then the excess gas can be directed to the MWOS by opening VM1 and then cracking V23 to pump gas out of the manifold. The manifold pressure should be maintained below 800 torr. Once the pressure in the manifold is stable and close to zero all hydrogen has been desorbed from the Ubed. The PT1 pressure curve can be used to reconfirm the capacity of the Ubed and hence the amount of active DU still present. All lines will be evacuated to prepare for the next step by opening valves V23, VM1, VM2, Ubed isolation valve, V21 and V22 until PT1 is below 2 torr.

The Ubed should now be left at 500 C for all further Oxygen and Hydrogen charging procedures to encourage the oxidation of the DU.

Oxygen Passivation

Oxygen is loaded onto the Ubed in a controlled manner by filling the evacuated manifold with oxygen from the O2 mass flow controller (MFC2). Valve VM1, V21 and V22 are opened and MFC2 is set for 0.2 SLPM of gas flow. When PT1 reaches 700 torr the oxygen supply is isolated by shutting VM1, V21, V22 and setting the MFC2 to 0 SLPM. The oxygen in the manifold is then exposed to the Ubed by opening valve VM2 and the Ubed isolation valve. The drop in pressure will determine the total volume of gas that is reacted within the Ubed and can be used to determine the amount of DU that is still active within the Ubed. If the pressure drops below 2 torr then repeat the same step with another charge of oxygen until the bed can no longer pump.

Once the pressure in the manifold is stable, all oxygen has been reacted with the DU. All lines will be evacuated to prepare for the hydrogen charge by opening valves V23, VM1, VM2, Ubed isolation valve, V21 and V22 until PT1 is below 2 torr and then close all valves.

The hydrogen wash and oxygen passivation steps are repeated alternatively while keeping the Ubed at 500 C until there is no more significant drop in pressure during both hydrogen and oxygen charging operation. At this point all of the DU in the Ubed will be oxidized and no longer pyrophoric. All gettered tritium has been removed from the DU. Residual tritium contamination of surfaces inside the Ubed will be in the nCi/kg to μCi/kg range The Ubed is now ready for final disposal. Close the Ubed isolation valve, turn off the Ubed heater, allow the Ubed to reach room temperature and then remove the Ubed from the system.

Final disposal

The fully unloaded Ubed will need to be prepared for final disposal. Remove all exterior tags and erase all exterior markings with methanol. Wash the exterior of the Ubed using a wet paper towel. Smear the top, sides and bottom of the Ubed and measure for residual surface activity. If the smears measure above 5,000 DPM/100cm^2 then re-wash and re-survey until the surface is clean. Tag the Ubed as low level waste and send for disposal as low level contaminated metal waste without the D003 code.

Processing Results

System Calibration

In order to validate the gas measurements from the Ubed a variety of calibrations were performed. There are three main diagnostics on the new system, volume of the lines, the pressure sensor and the tritium monitor.

The pressure sensor is a calibrated MKS Baratron attached to an MKS PR4000 controller that is connected into the bed unloading data acquisition system. Its accuracy is verified by a two point calibration: zero when the gauge is under hard vacuum and 760 torr when the gauge pressure is equilibrated with the ambient (measured) pressure. The pressure sensor accuracy was also cross checked against measurements from a calibrated sensor located at UofR during the unloading of the transport vessels.

The tritium monitor is a 5 cc wire cage ionization chamber with a calibrated preamplifier and tritium controller (DTM) that is wired into the data acquisition system. The tritium monitor was cross verified using activity to pressure curves that have been developed at UofR for this device. (Fusion Engineering and Design 109-111 (2016) 128-134, Shmayda et al)

The internal line volumes are significant in order to calculate total gas volumes. These volumes were calibrated using the pressure sensor and the expansion of gas through the different sections and a known calibrated volume of 0.5 L. The results of this measurement are shown in Table 1.

Table 1: System Volume Calibration

Section Name	Bounding Valves	Measured Volume (cc)
Main Manifold	VM1, VM3, VCP, Ubed isolation valve	188
Transport Manifold	VT1, VT2, VT3, VT4, VM3	13
Vacuum Manifold	VM1, V21, V23	198
Transport Vessel	VT1,2,3 or 4	452
Cryopump	VCP	40

Results Description

During the unloading and passivation procedures four things were determined:

- Volume and activity of the Ubed head space gas
- Volume and activity of the tritiated hydrogen unloaded from the Ubed
- Quantity of hydrogen that could be loaded onto the empty Ubed which in turn determines the amount of active DU
- DU passivation after successive H2 and O2 washes

The volume and activity measurement of the Ubed head space provides a rough estimate of the amount of activity on the Ubed when it was first disposed. As the tritium decays, the conditioned DU releases the radiogenic Helium-3 into the head space. Knowing the quantity of the helium-3 and the decay rate of tritium it is possible to gain a first order estimate on the

amount of tritium present on the Ubed at the time it was taken offline. This is measured in the first part of the Tritium Unloading procedure and is shown as the increase in pressure when the Ubed is first opened to the evacuated manifold.

The quantity and activity of the hydrogen unloaded from the Ubed is used to determine the total amount of activity that was stored on the Ubed as well the isotopic composition of tritium/hydrogen/deuterium mixture. Using the tritium monitor activity and the pressure in the know manifold volume allows a calculation of both. The activity and isotopic composition was also confirmed more accurately at UofR using a specialized gas chromatograph that can measure each hydrogen isotopologue. These results from UofR are used to calibrate the pressure, volume, activity measurements that are done on the system at NSSI for all future Ubed unloadings.

The volume of hydrogen that can be loaded onto the Ubed in the first hydrogen wash gives an accurate measure of the quantity of DU that is active. This cannot be derived from the first two results since it is not known whether the bed was fully loaded or not. By loading the Ubed to its maximum capacity, that is to say to UH_3, it is possible to calculate how much active depleted uranium remains from the quantity of hydrogen absorbed.

Finally it is important to prove that the Ubed has been fully unloaded of tritium and is chemically passivated and consequently the DU is no longer pyrophoric. This can be determined by the successive H2 and O2 washes. If there is no uptake of H2 and/or O2, then the Ubed is fully inert.

SWB-092 Unloading Results

The Ubed SWB-092 was connected to the system on May 27, 2017. The system lines were evacuated and the Ubed head space was opened to the manifold lines. The pressure in the manifold went from 2.4 torr to 274.4 torr and the activity went from 12 Ci/m^3 to 41 Ci/m^3. The total gas volume and activity calculation is shown in Table 2.

For this Ubed the head space seemed to have a significant amount of activity so the gas was not evacuated and was instead collected. The Ubed heater was turned on to unload the bed and as the Ubed went from room temp to 450 C all the gas was collected onto the cryopump. Once the Ubed was at temperature and all gas had been collected on the cryopump the Ubed was isolated and the cryopump was heated to drive the collected gas into the 0.5 L transport vessels filling vessel number 616 to 660 torr at 4000 Ci/m^3 and vessel number 617 to 246 torr at 2720 Ci/m^3. Vessel 616 was assayed at UofR to contain 0.36 sL of gas and 124.3 Ci of tritium and Vessel 617 was assayed to contain 0.13 sL of gas and 46.3 Ci of activity.

For the first hydrogen wash the Ubed was held at room temperature and all lines, gas manifold and Ubed was evacuated as per the procedure. The Ubed was then isolated and the manifold was charged and then loaded onto the Ubed in three separate loadings (see Fig 8). The loadings were 450 torr to 340 torr, 406 torr to 100 torr, and finally 533 torr to 60 torr for a total pressure loading of 889 torr. The calculation of the total gas absorbed and hence the estimate of active DU is in Table 2.

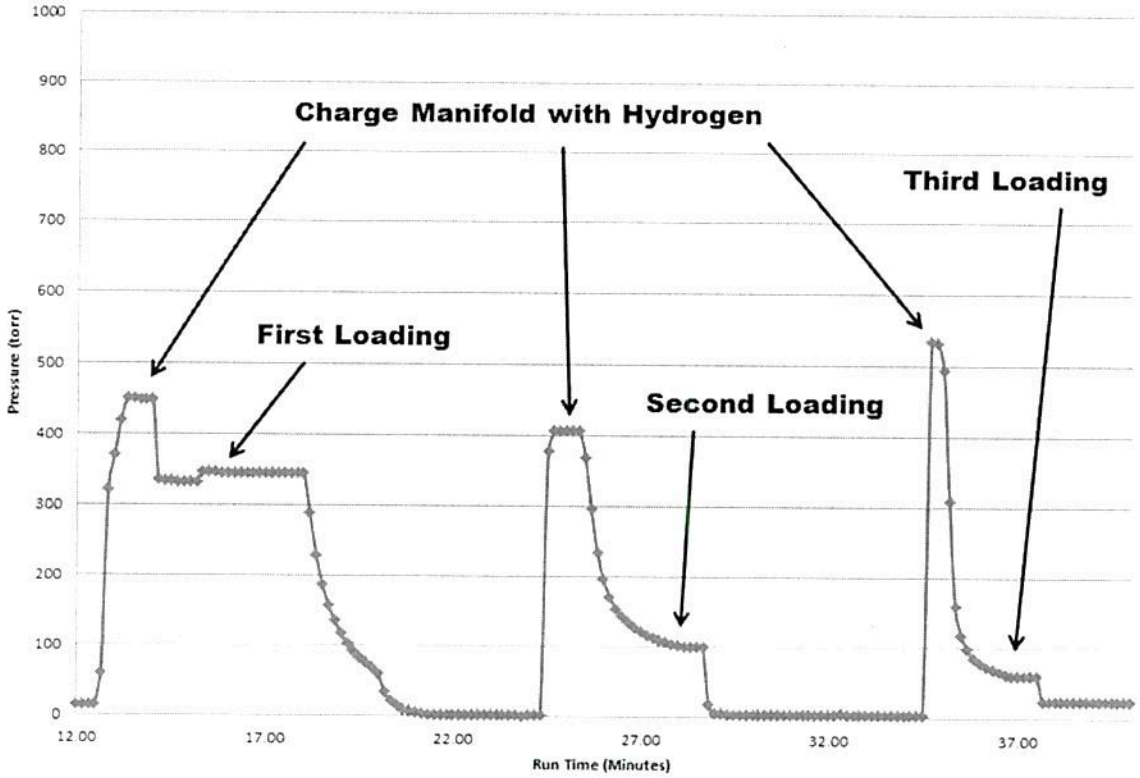

Figure 8: SWB-092 Hydrogen Loading

It is noteworthy that the first loading stalled at 340 torr even though there was significantly more active DU available. This behavior is characteristic of DU that has been exposed to a small quantity of air which coated the DU surface. The first loading helped break through this oxide layer to access the underlying DU.

Finally the Ubed was unloaded with the hydrogen to the MWOS and then passivated at 450 C with oxygen. At first it was attempted to passivate the Ubed with air to minimize the reaction of the DU but the presence of the nitrogen caused too much blanketing in the small Ubed and interfered with the passivation process so the air was replaced with pure oxygen as the passivating gas. All future Ubeds will be passivated with oxygen. The Ubed was then loaded and evacuated with successive rounds of hydrogen and oxygen until the Ubed showed no noticeable absorption of the oxygen (see Figure 9). The Ubed was fully unloaded and passivated. The Ubed was allowed to cool and was removed from the system for disposal preparation. As an aside, the pressure increase observed at long times after both oxygen and hydrogen introduction is related to gas heated in the loop by the hot Ubed.

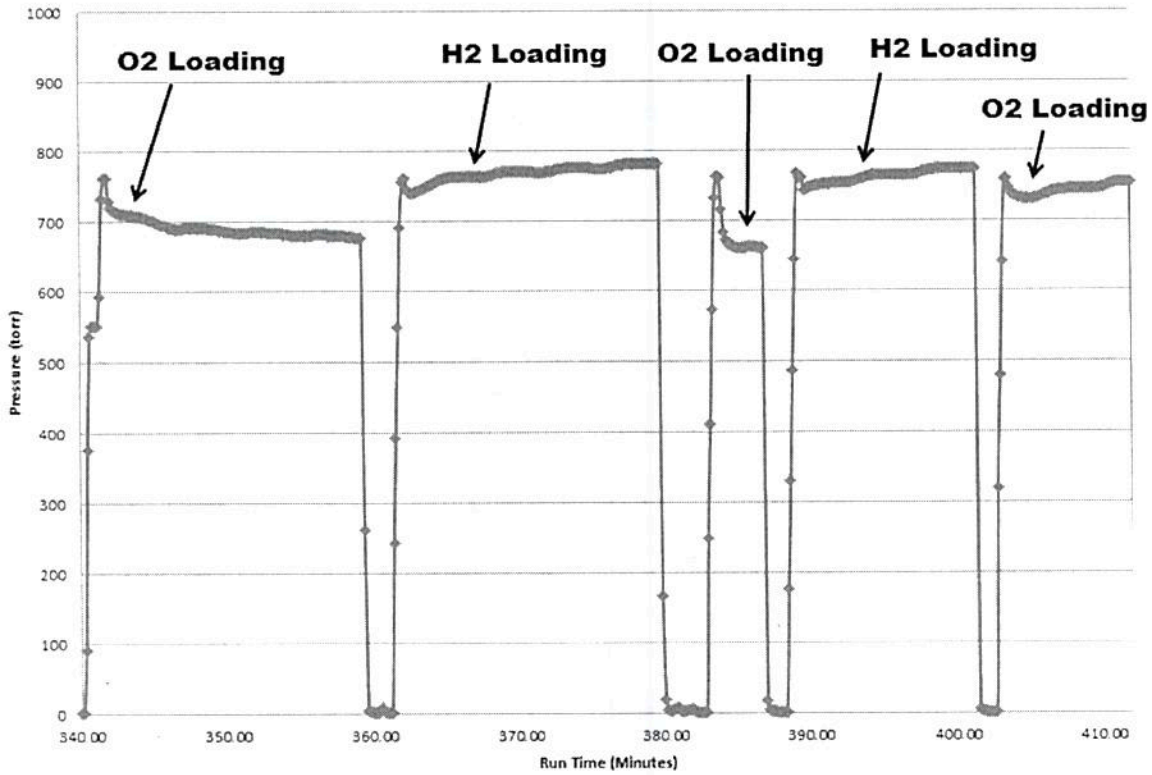

Figure 9: SWB-092 Passivation with H2 and O2

Table 2: SWB-092 Results

Item	Measured Value	Calculation	Result
Head Space Volume	272 torr	0.188 L x 272/760 x273/295	0.062 sL
Head Space Activity	0.029 Ci/sL		
TV616 Volume	660 torr	0.452 sL x 660/760 x 273/295	0.36 sL
TV 616 UofR Activity	124.3 Ci		
TV617 Volume	246 torr	0.452 sL x 246/760 x 273/295	0.13 sL
TV 617 UofR Activity	46.3 Ci		
H2 loading	889 torr	1.09 L x 889/760 x 273/295	1.18 sL
Active DU	1.18 sL of H_2 gas	1.18/22.41 mol_H2*2/3*238 g/mol_U	8.3 grams of DU

UNK-01 Unloading Results

The Ubed UNK-001 was connected to the system on July 28, 2017. The system lines were evacuated and the Ubed head space was opened to the manifold lines. The pressure in the manifold went from 2 torr to 5.8 torr with no measureable activity on the tritium monitor. The total gas volume is shown in Table 3.

For this Ubed the head space seemed to have no significant amount of activity so the gas was evacuated to the MWOS. Since there was so little volume in the head space the gas from the Ubed would be expanded directly into the manifold and the cryopump would not be used. The Ubed heater was turned on to unload the bed and as the Ubed went from room temp to 460 C all the gas was collected into the manifold. The manifold pressure went from 2 torr to 11 torr and no tritium activity was measured on TM1. The unloading from the Ubed was evacuated to the MWOS since there was no purpose to collect the gas in the transport vessel.

For the first hydrogen wash the Ubed was held at room temperature and all lines, gas manifold and Ubed was evacuated as per the procedure. To reduce the number of loadings both the primary manifold, transport manifold and transport vessels TV611 (total vol 700 cc) and then TV617 (total vol 1,200 cc) were charged with hydrogen and then loaded onto the Ubed. There were 10 loadings of hydrogen in succession (see Fig 10) before the Ubed was at capacity. The total amount of hydrogen volume is presented in Table 3 along with the calculation of the total amount of active DU.

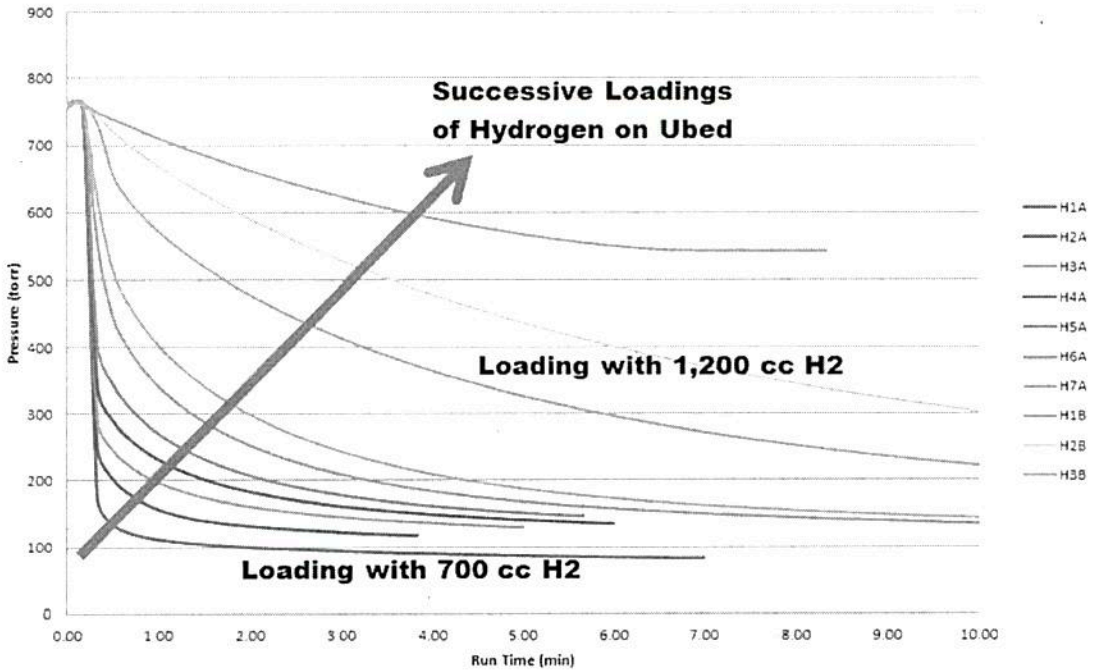

Figure 10: Successive Hydrogen Loadings of Ubed UNK-001

Finally the Ubed was unloaded with the hydrogen to the MWOS after confirming there was no activity in the gas and then passivated at 450 C with oxygen. The Ubed was then loaded and evacuated with successive rounds of hydrogen and oxygen until the Ubed showed no more significant absorption of the oxygen in the same manner as for Ubed SWB-092. The Ubed was now considered fully unloaded and passivated. The Ubed was allowed to cool and was removed from the system for disposal preparation.

Table 3: UNK-001 Results

Item	Measured Value	Calculation	Result
Head Space Volume	3.8 torr	0.188 sL x 3.8/760 x 273/295	0.001 sL
Head Space Activity	0	None	Negligible activity
H2 loading	4,442 torr at 700 cc 1,326 torr at 1,200 cc	700 x 4,442/760 *273/295 1,200 x 1,326/760 x 273/295	3.79 sL of gas 1.94 sL of gas Total 5.73 SL of H2
Active DU	5.73 sL of H2 gas	5.73/22.41 mol_H2*2/3*238 g/mol_U	40.6 grams of DU

Secondary Enclosure Volumes

Both the SWB-092 and UNK-001 were Ubeds with a secondary containment. The secondary containment had a valve connection to allow for the evacuation of the secondary volume. In order to confirm that there was no outgassed tritium in the secondary enclosure, both Ubed secondary volumes were evacuated and back filled with air. In both cases there was no measureable tritium activity in the secondary volume space.

Total Capture Efficiency

During all operations the only effluent from the procedures has been through the MWOS. The outlet of the MWOS is monitored by a low level tritium activity monitor. The entire facility is also monitored using a compliance stack monitor with bubbler system. During the course of the work no significant tritium activity was measured at the MWOS exhaust. The operation recovered 171.7 Ci of tritium. Approximately 15 Ci of tritium gas were discharged to the MWOS where it was converted to water and collected on driers without any noticeable emission to the tritium laboratory stack. The capture efficiency for these operations exceeded 10^4.

Conclusions

The Ubeds SWB-092 and UNK-001 that were delivered to NSSI for disposal have had more than 99.999% of all tritium activity unloaded and recycled back into the fusion community at UofR. The total activity and quantity of each Ubed is summarized in Table 4.

Table 4: Final U Bed Accounting

Ubed	Total Tritium Activity	Total Active DU
SWB-092	170.6 Ci	8.3 g
UNK-001	1.1 Ci	40.6 g

More than 99.9% of all depleted uranium was passivated and no longer pyrophoric. The total passivation was determined through a fundamental absorption measurement.

The Ubeds were cleaned of all surface contamination and have been prepared for final disposal as non-radioactive (that is to say with < 10 μCi of tritium /kg of metal). The radioactive emission from the Ubeds is dominated by gamma emission from the depleted uranium with a dose of < 1 mrem on contact.